Physicsaholics

DPP – 3

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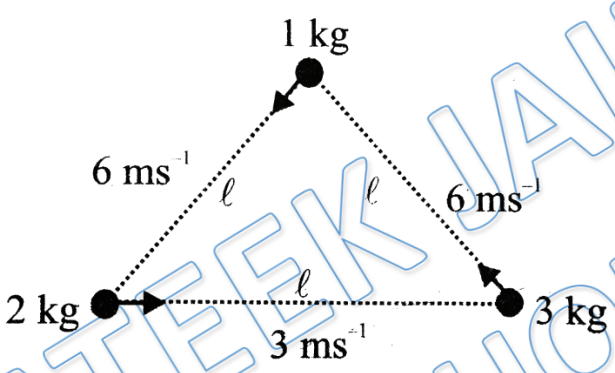
Q 1. Three particles of masses 1 kg, 2 kg and 3 kg are situated at the comers of an equilateral triangle move at speed 6 m/s, 3 m/s and 2 m/s respectively. Each particle maintains a direction towards the particle at the next comer symmetrically. Find velocity of CM of the system at this instant

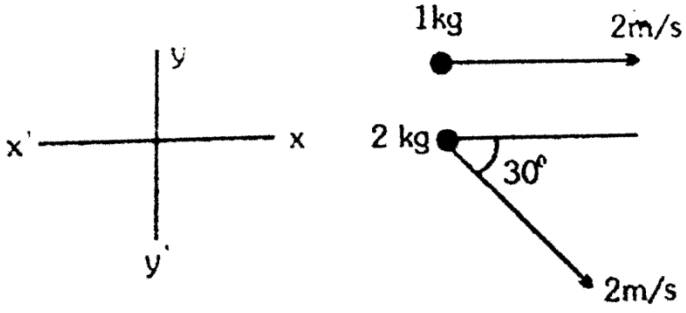


(a) 3 m/s (b) 5 m/s
(c) 6 m/s (d) zero

Q 2. Four particles of masses 1 kg, 2 kg, 3 kg, and 4 kg are situated at the corners of a square and moving at speed 3 m/s, 4 m/s, 1 m/s and 2 m/s respectively. Each particle maintains a direction towards the particle at the next comer symmetrically. The speed of the com at this instant is

(a) 3 m/s (b) 5 m/s
(c) 6 m/s (d) zero

Q 3. The velocity of center of mass of the system as shown in the figure :-



(a) $\left(\frac{2-2\sqrt{3}}{3}\right)\hat{\imath} - \left(\frac{1}{3}\right)\hat{\jmath}$

(b) $\left(\frac{2+2\sqrt{3}}{3}\right)\hat{\imath} - \left(\frac{2}{3}\right)\hat{\jmath}$

(c) $4\,\hat{\imath}$

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(d) none of these

Q 4. Two particles of mass 1kg and 2kg are moving along the same line with speeds 2m/s and 4m/s respectively. Calculate the speed of the center of mass of the system if both the particles are moving in the same direction

(a) 10 m/s (b) 3 m/s

(c) $\frac{10}{3}$ m/s (d) $\frac{3}{10}$ m/s

Q 5. Two bodies of masses 2 kg and 1 kg are moving along the same line with speeds 2m/s and 5m/s respectively. What is the speed of the center of mass of the system if the two bodies are moving in opposite directions?

(a) 3 m/s (b) 1 m/s

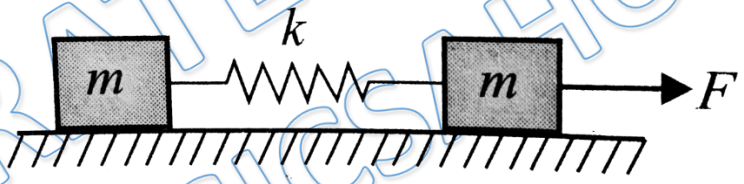
(c) $\frac{2}{3}$ m/s (d) $\frac{1}{3}$ m/s

Q 6. Two particles of masses 2 kg and 4 kg are approaching each other with acceleration `1 m/$s^2$` and `2 m/$s^2$`, respectively, on a smooth horizontal surface. Find the magnitude of acceleration of center of mass of the system

(a) 1 m/s^2 (b) 2 m/s^2

(c) 3 m/s^2 (d) 4 m/s^2

Q 7. Initially system is in rest and an external force F is applied on mass m. Then the displacement of the center of mass of system at time t is :



(a) $\frac{Ft^2}{2m}$ (b) $\frac{Ft^2}{3m}$

(c) $\frac{Ft^2}{4m}$ (d) $\frac{Ft^2}{m}$

Q 8. A body of mass 2.5 kg is subjected other forces shown in figure. Find the acceleration (approx.) of the Centre of mass

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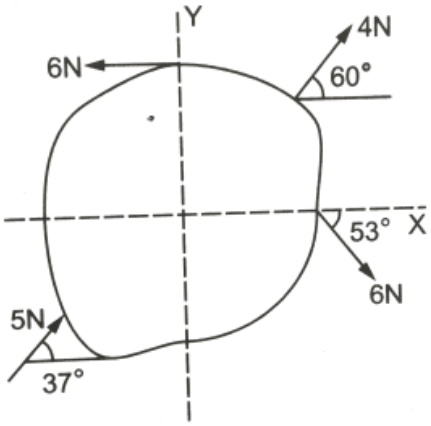

(a) 2.1 m/s^2 (b) 3.5 m/s^2
(c) 0.7 m/s^2 (d) 1.5 m/s^2

Q 9. Two bodies of mass 3kg and 4kg are suspended at the ends of massless string passing over a frictionless pulley. The acceleration of the center of mass of system is (g = 9.8 m/s^2)

(a) $\frac{g}{7}$ downward (b) $\frac{g}{49}$ downward
(c) $\frac{g}{14}$ downward (d) $\frac{g}{14}$ upward

Q 10. In a system of particles 8 kg mass is subjected to a force of 16 N along +ve x−axis and another 8 kg mass is subjected to a force of 8 N along +ve y−axis. The magnitude of acceleration of center of mass and the angle made by it with x−axis are given respectively by

(a) $\frac{\sqrt{5}}{2}\ m/s^2, \theta = 45^0$ (b) $3\sqrt{5}\ m/s^2, \theta = \tan^{-1}\left(\frac{2}{3}\right)$
(c) $\frac{\sqrt{5}}{2}\ m/s^2, \theta = \tan^{-1}\left(\frac{1}{2}\right)$ (d) $1\ m/s^2, \theta = \tan^{-1}(\sqrt{3})$

Q 11. Two bodies of masses 5kg and 3kg are moving towards each other with 2m/s and 4m/s respectively. Then velocity of center of mass is

(a) 0.25 m/s towards 3 kg (b) 0.5 m/s towards 5 kg
(c) 0.25 m/s towards 5 kg (d) 0.5 m/s towards 3 kg

Q 12. Two identical particles move towards each other with velocity 2v and v respectively. The speed of center of mass is

(a) v (b) $\frac{v}{3}$
(c) $\frac{v}{2}$ (d) zero

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Answer Key

Q.1 d	**Q.2 d**	**Q.3 b**	**Q.4 c**	**Q.5 d**
Q.6 a	**Q.7 c**	**Q.8 d**	**Q.9 b**	**Q.10 c**
Q.11 c	**Q.12 c**			

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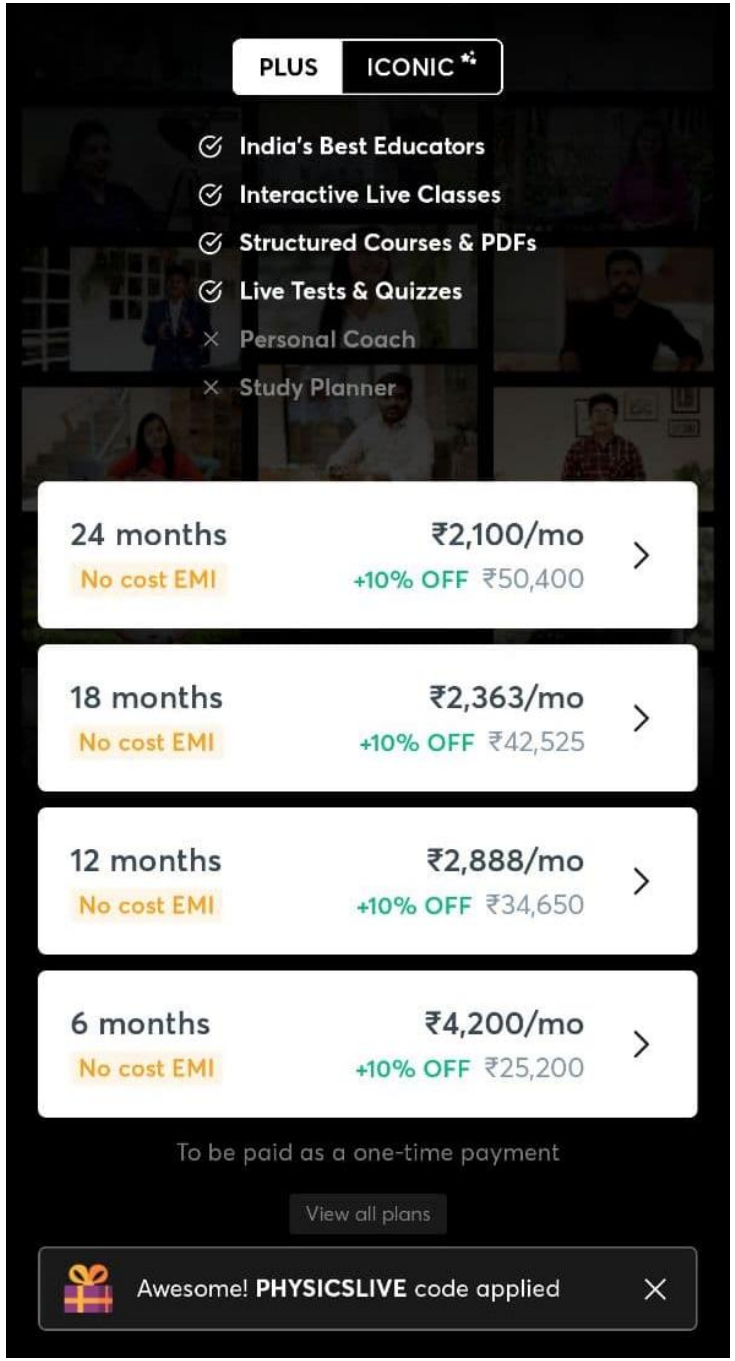


Written Solution

DPP-3 COM: Motion of Center of Mass

By Physicsaholics Team

Solution: 1

$$V_x = \frac{m_A(V_A)_x + m_B(V_B)_x + m_C(V_C)_x}{m_A + m_B + m_C}$$

$$V_x = \frac{(2\times 3) + 1\times(-6\sin 30^\circ) + 3\times(-2\cos 60^\circ)}{2+1+3}$$

$$V_x = \frac{6 - 3 - 3}{6} = \frac{0}{6} = 0$$

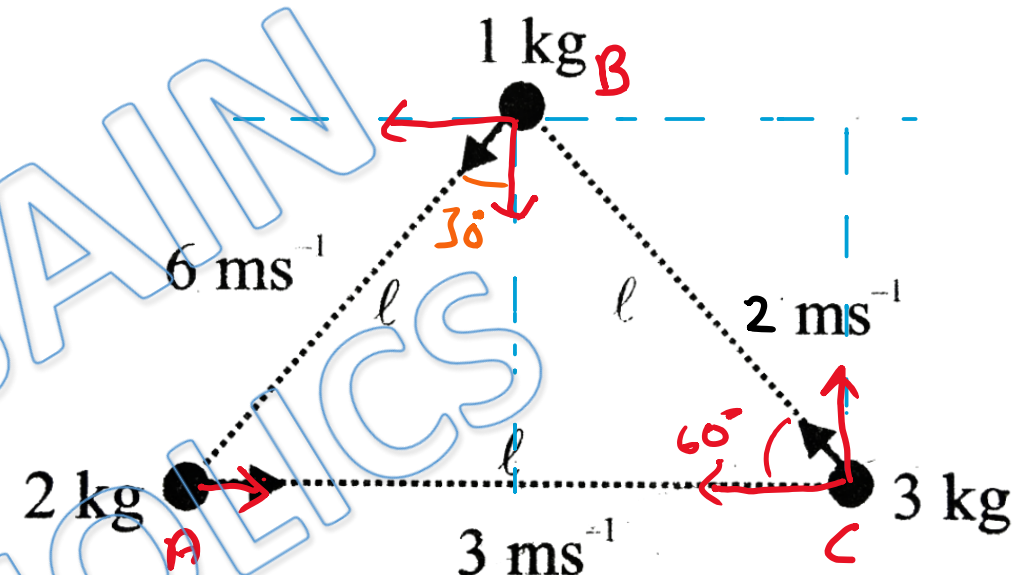
$$\boxed{V_x = 0 \text{ m/s}}$$

$$V_y = \frac{(2\times 0) + 1(-6\sin 30^\circ) + 3(2\sin 60^\circ)}{2+1+3} = \frac{0 - 3\sqrt{3} + 3\sqrt{3}}{6}$$

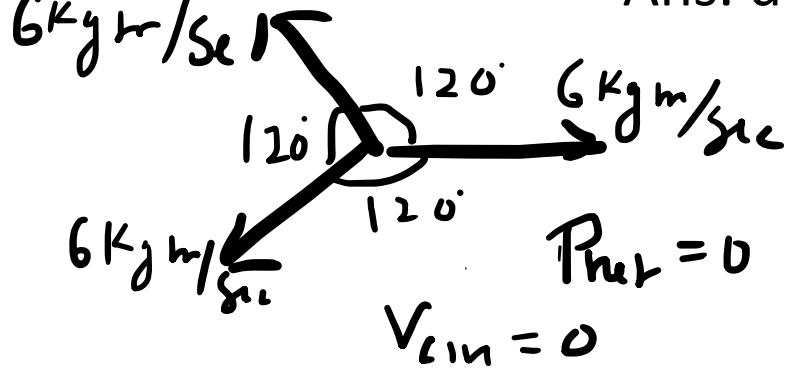
$$\boxed{V_y = 0 \text{ m/s}}$$

$$V = \sqrt{V_x^2 + V_y^2} = \sqrt{0^2 + 0^2}$$

$$\boxed{V = 0} \quad \text{Ans.}$$



OR



Ans. d

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Solution: 2

$$v_x = \frac{(1\times 3)+(4\times 0)+(3\times(-1))+(4\times 0)}{1+2+3+4}$$

$$v_x = \frac{3-3}{10} = 0$$

$$\boxed{v_x = 0 \text{ m/s}}$$

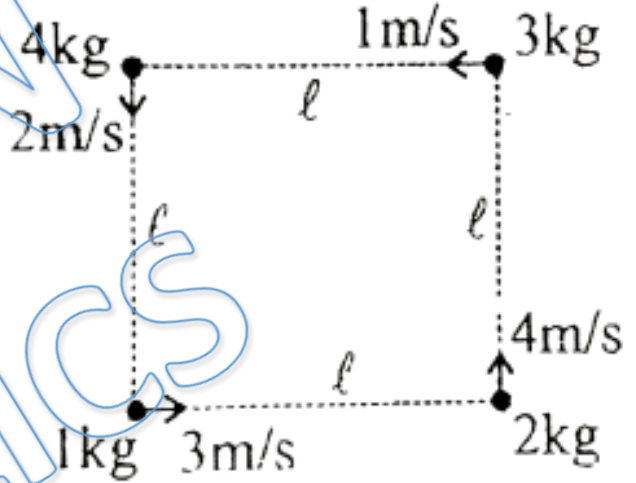
$$v_y = \frac{(1\times 0)+(2\times 4)+(3\times 0)+(4\times(-2))}{10}$$

$$= \frac{8-8}{10} = 0$$

$$\boxed{v_y = 0 \text{ m/s}}$$

$$v = \sqrt{v_x^2 + v_y^2}$$

$$\boxed{v = 0 \text{ m/s}}$$ Ans.



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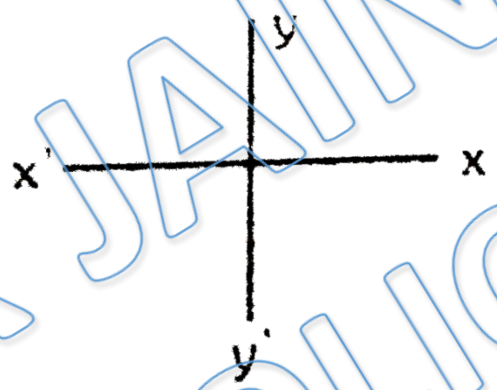
Ans. d

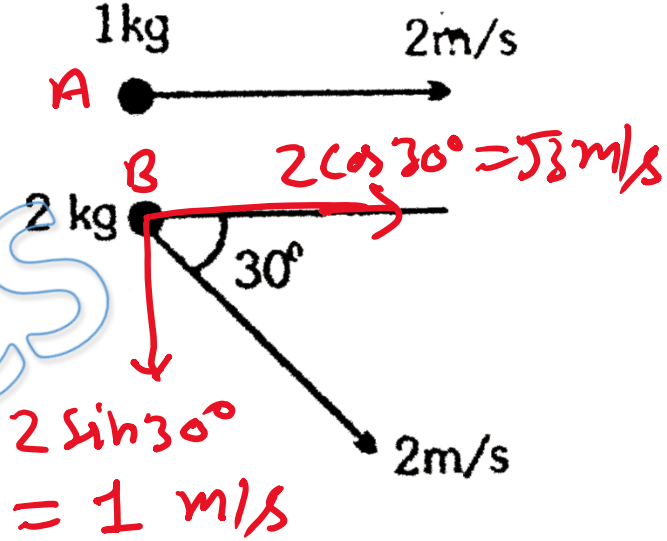
Solution: 3

$$\vec{V}_{cm} = \frac{m_1\vec{v}_1 + m_2\vec{v}_2}{m_1 + m_2}$$

$$\vec{V}_{cm} = \frac{1(2\hat{i}) + 2(\sqrt{3}\hat{i} - 1\hat{j})}{3}$$

$$\boxed{\vec{V}_{cm} = \left(\frac{2+2\sqrt{3}}{3}\right)\hat{i} - \frac{2}{3}\hat{j}} \quad \text{Ans.}$$





Ans. b

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Solution: 4

$$V_{cm} = \frac{(1 \times 2) + (2 \times 4)}{1+2}$$

$$V_{cm} = \frac{2+8}{3}$$

$$\boxed{V_{cm} = \frac{10}{3}\ m/s}$$ Ans.

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Ans. c

Solution: 5

$$V_{cm} = \frac{(1 \times 5) - (2 \times 2)}{1+2}$$

$$V_{cm} = \frac{5-4}{3}$$

$$\boxed{V_{cm} = \frac{1}{3} \text{ m/s}} \quad \text{Ans.}$$

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Ans. d

Solution: 6

$$a_{cm} = \left| \frac{m_1 a_1 + m_2 a_2}{m_1 + m_2} \right|$$

$$a_{cm} = \left| \frac{2 \times 1 + 4 \times (-2)}{2 + 4} \right| = \left| \frac{-6}{6} \right|$$

$$\boxed{a_{cm} = 1 \text{ m/s}^2} \quad \text{Ans.}$$

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Ans. a

Solution: 7

$F_{ext} = F$

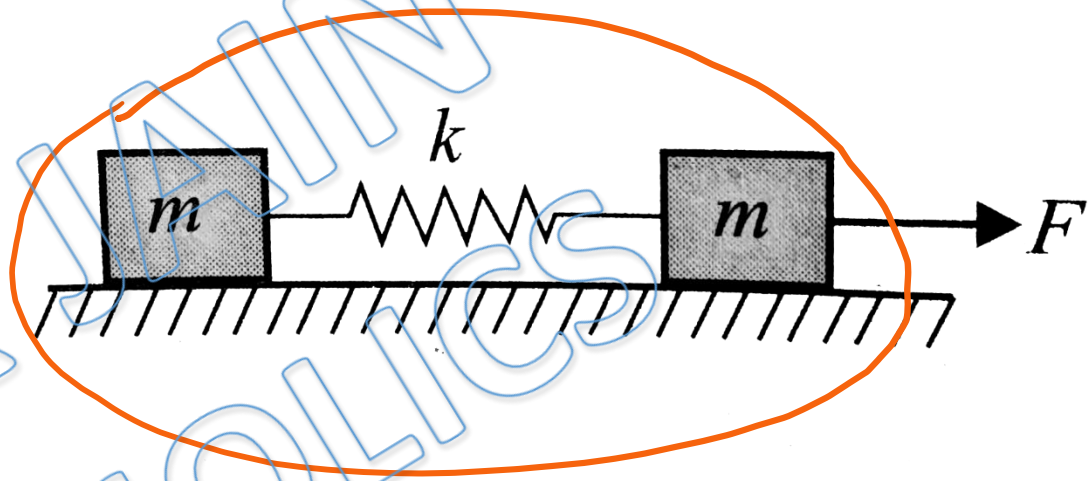
$M = 2m$

$a_{cm} = \frac{F}{M} = \frac{F}{2m}$

$s_{cm} = \cancel{u_{cm}}^{0} t + \frac{1}{2} a_{cm} t^2$

$s_{cm} = \frac{1}{2}\left(\frac{F}{2m}\right) t^2$

$$\boxed{s_{cm} = \frac{F t^2}{4m}}$$ Ans.



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Ans. c

Solution: 8

$$(a_x)_{cm} = \frac{(F_x)_{ext}}{M} = \frac{2 + \frac{18}{5} + 4 - 6}{2.5}$$

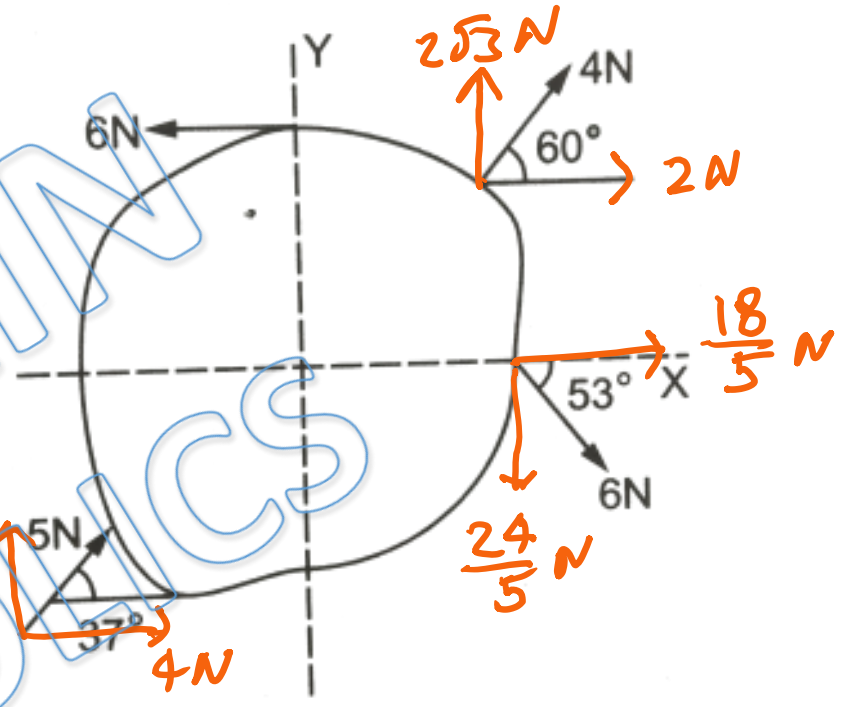
$$(a_x)_{cm} = \frac{18}{5 \times 2.5} = \frac{36}{25} = 1.44 \text{ m/s}^2$$

$$(a_y)_{cm} = \frac{(F_y)_{ext}}{M} = \frac{2\sqrt{3} + 3 - \frac{24}{5}}{2.5}$$

$$(a_y)_{cm} = 0.66 \text{ m/s}^2$$

$$a_{cm} = \sqrt{(a_x)_{cm}^2 + (a_y)_{cm}^2} = \sqrt{(1.44)^2 + (0.66)^2}$$

$$\boxed{a_{cm} \simeq 1.5 \text{ m/s}^2} \text{ Ans.}$$



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Ans. d

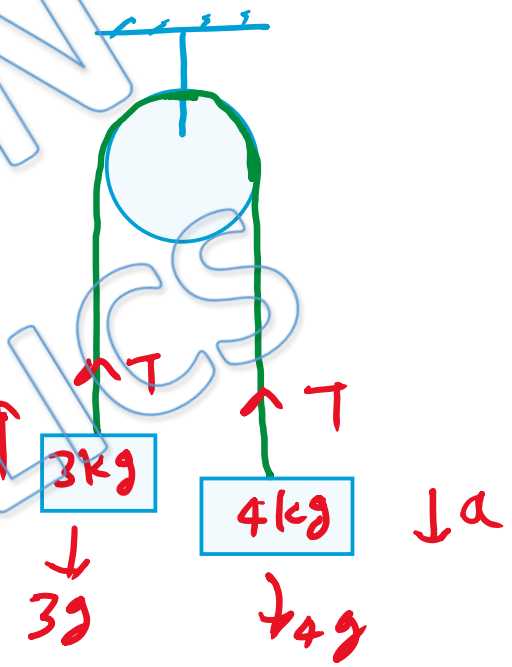
Solution: 9

$4g - T = 4a$

$T - 3g = 3a$

$g = 7a$

$$\boxed{a = \frac{g}{7}}$$



$$a_{cm} = \frac{m_1 a_1 + m_2 a_2}{m_1 + m_2}$$

$$a_{cm} = \frac{3 \times \frac{g}{7} - 4 \times \frac{g}{7}}{3+4} = \frac{-g/7}{7}$$

$$\boxed{a_{cm} = -\frac{g}{49}}$$

(-ve sign shows that acceleration will be downward)

Ans.

Ans. b

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Solution: 10

$$\vec{a}_{cm} = \frac{(\vec{F}_{ext})}{M} = \frac{16\hat{i} + 8\hat{j}}{16}$$

$$\boxed{\vec{a}_{cm} = \hat{i} + \frac{1}{2}\hat{j}}$$

$$a_{cm} = \sqrt{1^2 + \left(\frac{1}{2}\right)^2} = \sqrt{\frac{5}{4}}$$

$$\boxed{a_{cm} = \frac{\sqrt{5}}{2}\ m/s^2} \quad \text{Ans.}$$

$$\tan\theta = \frac{a_y}{a_x} = \frac{1/2}{1}$$

$$\tan\theta = 1/2$$

$$\boxed{\theta = \tan^{-1}\left(\frac{1}{2}\right)} \quad \text{Ans.}$$

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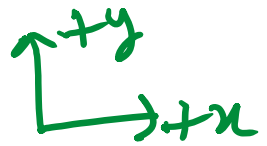
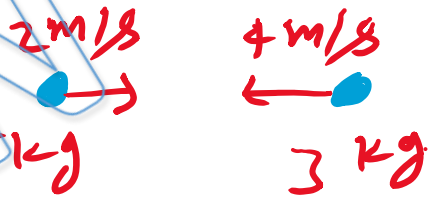
Ans. c

Solution: 11





$$v_{cm} = \frac{m_1 v_1 + m_2 v_2}{m_1 + m_2}$$

$$v_{cm} = \frac{5 \times 2 - 4 \times 3}{5 + 3}$$

$$v_{cm} = \frac{-2}{8} = -\frac{1}{4} = -0.25 \text{ m/s}$$ (-ve means; it's direction is towards 5 kg)

$v_{cm} = 0.25$ m/s towards 5 kg Ans.

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Ans. c

Solution: 12

speed of COM

$$v_{cm} = \left| \frac{m_1 v_1 + m_2 v_2}{m_1 + m_2} \right|$$

$$= \frac{m \times 2v - m \times v}{m + m}$$

$$v_{cm} = \frac{mv}{2m}$$

$$\boxed{v_{cm} = \frac{v}{2}}$$ Ans.

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Ans. c

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